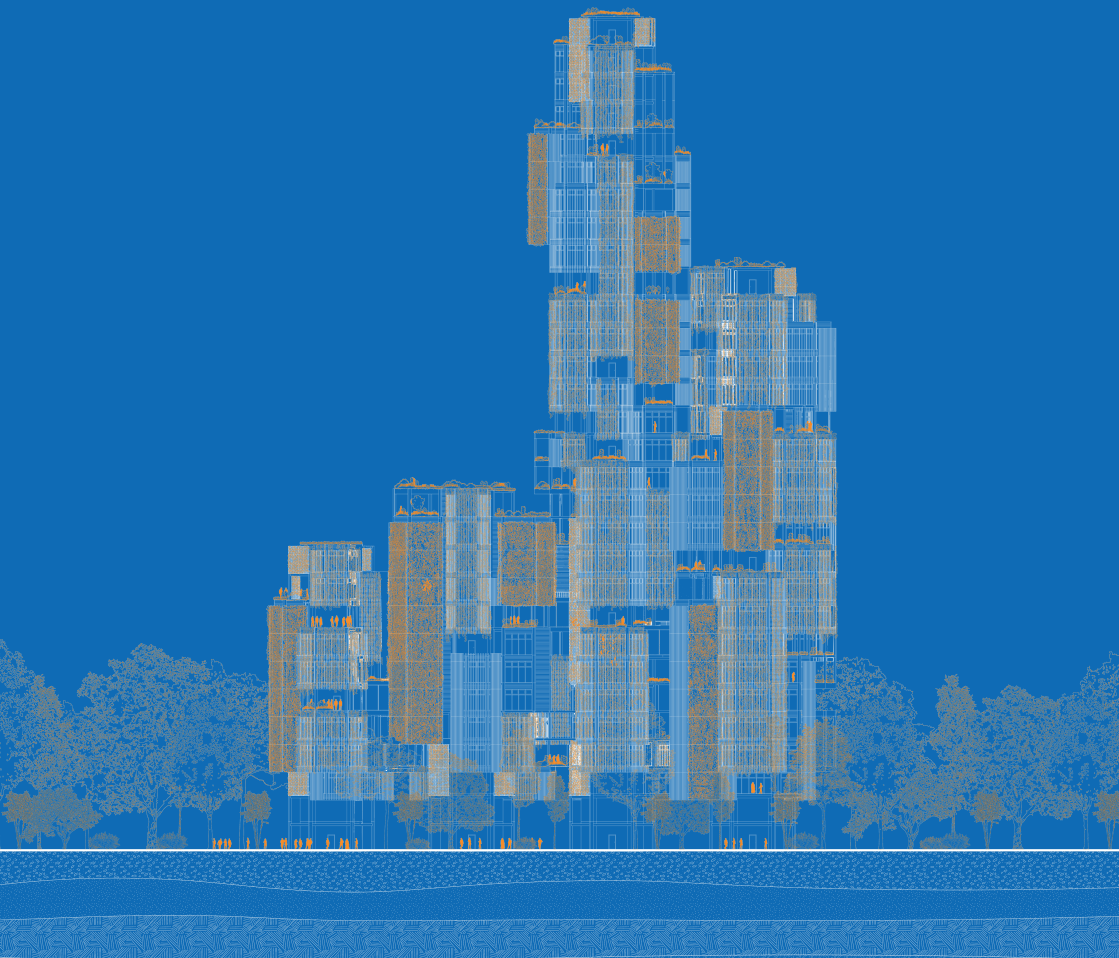


BIOPHILIC SPACE CATALOGUE

- Campus of Wellbeing -



BIOPHILIC SPACE CATALOGUE

- Campus of Wellbeing -

Additional Research Document | Master Thesis

Title: Campus of Wellbeing: The Biophilic Knowledge Hub

Studio: Public Building Graduation Studio 2023-24 |
The Vertical Campus: A Public Hub of the Future in The Hague

Delft University of Technology
Faculty of Architecture and the Built Environment

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Professor: Nathalie de Vries

[Drawings and Images are produced by the author unless stated otherwise.]



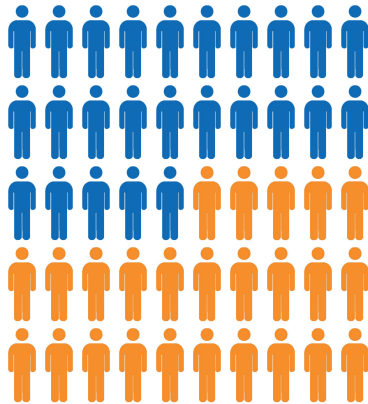
Fig. 1 In 1969, the *People's Park Protests* took place in Berkeley, involving students and public who were demonstrating for the creation of an open park on land originally owned by the University of California, which was met with police violence.

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1 | Wellbeing and Biophilic Design

Campus

Mental Health Issues



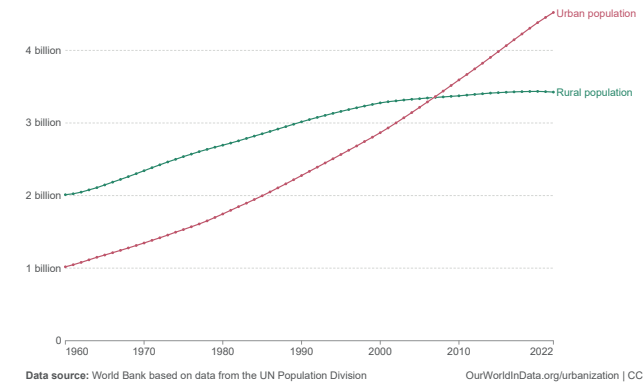
In 2021, 51% of the students in higher education reported Mental Health Issues in the Netherlands.

(Source: RIVM, 2021)

Mental health is “a state of mental well-being that enables people to cope with the stresses of life, realize their abilities, learn well and work well, and contribute to their community” and “is more than the absence of mental disorders” (WHO, 2022).

Vertical

Urban Densification



[Fig. 2]

By 2050, the UN predicts that about 68% of the world population will live in cities – in 2018, it was 55%.

(Source: United Nations, 2018)

The growth of cities can happen horizontal or vertical. Building vertical allows to densify cities, while having a low footprint. On the other hand, there are climatic issues coming with it such as the heat-island effect which includes higher air pollution and temperatures inside of cities.

Biophilia, when translated directly from ancient Greek, means “love of life”. The term was first mentioned by the social psychologist Erich Fromm, who defined it as “The passionate love of life and of all that is alive; it is the wish to further growth, whether in a person, a plant, an idea, or a social group” (Fromm, 1964). While Fromm characterized this idea mainly on a psychological level, the biologist Edward O. Wilson set it into the context of “evolutionary adaptation” (Babiero and Berto, 2021) and defined it as “the innate tendency to focus on life and lifelike processes” (Wilson, 1984, p.1), which is based on the history of humankind evolving from and living in natural environments for millennia (Kellert, 2018) .

During the 1980s and 1990s, these conceptual developments of an biophilic idea were accompanied by research in the field of environmental psychology, where studies have been conducted about a possible correlation of natural elements and settings, with an increase of humans’ wellbeing and health when exposed to those (Zhong et al., 2022). One of these studies for example tested how different window views might affect the healing process of patients after having surgery in a hospital in Pennsylvania. The results indicated that patients who had a window view to a natural environment recovered in average faster compared to patients who had an urban view (Ulrich, 1984).

Edward O. Wilson’s (1984, 1993) and Stephen R. Kellerts (1993) definition and theory of Biophilia, and the research on a link between ‘nature’ and human health, served as a base for the development of an architectural concept called Biophilic Design (Zhong et al., 2022).

Biophilic Design deals with the interface between Biophilia and nature’s influence on wellbeing, and how this concept can be translated into the design of the physical world. It’s about how the ideas can be utilized in designing healthier environments. While the theory focuses on the one side on the human perspective and their health benefits, on the other hand, it’s also a design approach that aims to create holistic and sustainable architecture that includes various organisms such as vegetation, animals, or becoming part of an ecosystems (Kayihan, 2018), hence a Biocentric Worldview.

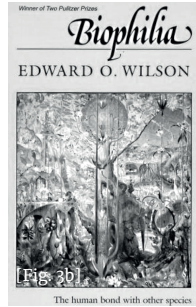
Heerwagen and Hase (2001) were the first who have written about the idea of “Biophilic Buildings” and how to bring the concept of Biophilia into the built environment. Practically, the idea aims to design spaces that are focused on including natural daylight, ventilation, vegetation or imitating natural features and forms (Kellert et al., 2008). Some of these aspects are evidence-based researched with the result to evoke positive biological responses that enhance wellbeing, whereas other parts are still being conducted in need of more quantitative research (Zhong et al., 2022).

Although the term Biophilic Design was mentioned just about 20 years ago, the ideas and design patterns that are part of this concept, such as the use of natural daylight or the implementation of greenery into architecture, are already existing for centuries: Adding gardens or green courtyards, the fascination with the myth of the Hanging Gardens of Babylon, or Frank Lloyd Wright’s Fallingwater House (Zhong et al., 2022).

History of Biophilic Design

1980s

Environmental Psychology
is doing more research
on how nature influences
human wellbeing, beginning
in the 1980s and 90s.



1984

The **Biophilia Hypothesis**
was published
(Wilson, 1984).

2001

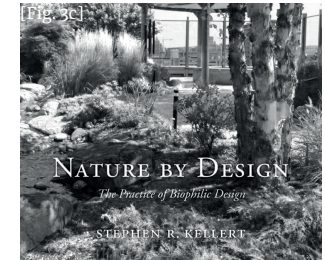
Heerwagen and Hase (2001) published an article describing the idea of **Biophilic Buildings**

2008

Stephen Kellert (2008) as well as Cramer and Browning (2008) publish research papers on various Biophilic Design Patterns for the built environment.

2018

Book release: “**Nature by Design**: the practice of biophilic design” (Kellert, 2018).



1964

For the first time the term **'Biophilia'** (1964) was mentioned by the social psychologist Erich Fromm.



1972

The first **United Nations World Conference** with 'environment' as its main topic is happening in Stockholm.

2020

Human-made mass exceeds the global **Biomass** (Elhacham et al., 2020).

2018

The United Nations publishes a report with predictions that by **2050 about 68%** of the global population **will live in cities**.

2015

The **Sustainability Development Goals** (SDG) were adopted by all 193 United Nations Member States.



[Fig. 3f]

1854

The **Industrial Revolution** in the 19th century changed people's life drastically. The American philosopher Henry Thoreau published a book "Walden" (1854) in where he writes about **Holistic Worldview** in harmony with nature (Cunningham, 2022).

1953

Environmental Crises
such as the Great Smog in London started to create a wider public environmental awareness (Weyler, 2018).



1972

The **Club of Rome**, a group of scientists, predicts that if the world grows as it does, the latest by 2100, the world won't be able to sustain the global population and its ecosystem (Meadow et al., 1972).



Global Developments

[Fig. 3 The timeline explains the origin of Biophilic Design based in its historical context.]

Humans

Psychological | Cognitive | Physical

- + Mental Health (*Bratman et al., 2012*)
- + Physical Health (*Barton & Pretty, 2010*)
- + Cognitive Performance (*Berman et al., 2008*)
- + Attention Restoration (*Kaplan, 1995*)
- + Creativity (*Williams et al., 2018*)
- + Academic Performance (*Tennessen and Cimprich, 1995*)
- + Stress Reduction (*Yao et al., 2021*)

Environment

City | Animals | Vegetation

- + Biodiversity (*Fuller et al., 2007*)
- + Mitigates the Heat-Island Effect / Cooling (*Park et al., 2017*)
- + 'Sponge-City' / Water Management (*Foster et al., 2011*)
- + Decrease of Energy Consumption (*Hoelscher et al., 2016*)

2 | Biophilic Design Patterns

After a general literature research about the interrelations between nature, Biophilic Design and human health, as well as the positive effects on the environment, I was looking for ways on to translate this knowledge into actual architectural actions or spaces for the Vertical Campus in The Hague, in specific a “Campus of Wellbeing”.

Therefore, in the next step I studied existing Biophilic Design Frameworks (Kellert, 2008; Ryan et al., 2014; Zhong et al., 2022). These frameworks present general design patterns as a base for architects to implement biophilic ideas into architecture, and thus enable to connect theory to practical and spatial applications (Ryan et al., 2014).

Using design patterns to transfer concepts is a common tool in architecture which is used since centuries (Ryan et al., 2014) and an example for this is the book called “A pattern language” (Alexander et al., 1977) . However, these Biophilic Design Patterns are not formulas that allow to calculate the exact amount of indoor plants that will evoke a certain biological response, but it’s a conglomeration and result of combining evidence-based research into recommendations and guidelines for designers (Ryan et al., 2014). Nevertheless, they are also mostly still missing to address how these patterns could be actually translated into specific architectural “form, typology, scale, proportion, tectonics and technology” (Zhong et al., 2022).

For my ‘Biophilic Space Catalogue’, I’m using the “optimised biophilic design framework” by Zhong et al. (2022), which is based on previous developed Biophilic Design Patterns that they have reviewed and revised. This will become a part of the system for my Biophilic Space Catalogue.

In this chapter, I will explain the different aspects of their framework including further literature research on some aspects regarding their impact on wellbeing. The framework is divided into three overall design approaches consisting of several elements that will help afterwards to formulate actual design actions.

Biophilic Design Framework by Zhong et al. (2021)
including Kellert’s (2018; 2008) terminology:

1. Nature Incorporation / Direct:

Water; Air; Daylight; Plants; Animals;
Landscape; Weather; Time and seasonal changes

2. Nature Inspiration / Indirect:

Forms and shapes; Patterns and geometries;
Mechanisms; Images; Materials, texture and colour

3. Nature Interaction / Experience:

Prospect and refuge; Complexity and order;
Enticement (peril and mystery); Connection to place;
Connection of spaces

The design approach of 'Nature Incorporation' or 'Direct Nature Experience' is using elements which are included inside of architecture. With that is either meant the direct contact with environmental features such as plants or animals, or multi-sensory experiences by utilizing natural daylight, ventilation or window views that show natural landscapes that approach various senses. (Zhong et al., 2022; Kellert, 2018; Kellert et al., 2008)

Water	- Implementing blue space features such as fountains or ponds; view and sound have a positive impact on wellbeing and restoration (Völker and Kistemann, 2011)
Air	- Using preferably natural ventilation through operable windows or inside-outside connections; good air quality improves cognitive performance and prevents mental fatigueness (Allen et al., 2016)
Daylight	- Utilizing natural lighting in variations to create different atmospheres through transparency, translucency and shadows; it promotes productivity and wellbeing, and is crucial for the biological system of the human body (Edwards & Torcellini, 2002)
Plants	- Can be included indoors or outdoors in form of green facades and roofs, or also gardening - considering local vegetation; indoor plants can reduce stress, enhance wellbeing or foster creativity (Qin et al., 2013)
Animals	- Through greenery such as plants, living walls and green roofs biodiversity can be improved (Zhong et al., 2022); Biodiversity seem to be linked to human health (Sandifer et al., 2015)
Landscape	- Either the inclusion of the surrounding landscape through window views and inside-outside connections or through interior design (Kellert, 2018)
Weather	- Staying connected to the outside weather conditions or simulating different experiences (Zhong et al., 2022)
Time/Season	- The building is adapting during the seasons when plants lose their leaves; creates temporality and authenticity (Zhong et al., 2022)

Besides a direct implementation of natural elements into a building design, architects can also use the idea of 'Nature Inspiration' or 'Indirect Experience of Nature'. This approach links partially to the concept of Biomimicry, which means overall to mimic and to inspiration from either natural forms, (eco-)systems, concepts or processes. Moreover, it can mean to apply biobased materials and natural colors, or to design a haptic experience with various textures. Additionally, it can be used as symbols and metaphors, which can connect to the place and geology, and culture by creating identity. (Zhong et al., 2022; Kellert, 2018; Pawlyn, 2019)

- | | |
|--------------------------------------|---|
| Forms and Shapes | - Imitating organic forms and shapes in different scales from building envelope to interiors inspired by plants, animals or natural structures such as cells - using for example spirals, arches or vaults; can enhance contextuality or give identity to space (Zhong et al., 2022) |
| Patterns and Geometries | - Using mathematical properties of nature to define proportions or hierarchy that can create a sense of balance and harmony; this can be for example the use of geometric patterns, fractals or using proportions that get close to the Golden Ratio (Kellert, 2018) |
| Mechanisms | - It's related to the field of 'Biomimetics' and means to draw inspiration from natural systems to optimize the technological aspect in terms of structural efficiency or indoor climate (Pohl & Nachtigall, 2015) |
| Images | - Studies have shown that depictions of natural scenes or elements can enhance general wellbeing (Mygind et al., 2019); additionally, it was also tested how immersive nature experiences (virtual reality) can also have a positive impact on the cognitive performance (Yin et al., 2018) |
| Materials, Texture and Colour | - Applying natural materials such as wood, stone or clay; working with different textures to create sensory rich spaces; certain colors and materials can reduce stress or affect learning (Gaines & Curry, 2011; Tsunetsugu et al., 2007; Sakuragawa et al., 2005) |

The third category of this Biophilic Design Framework deals with the idea of general spatial articulations based on natural principles and is called 'Nature Interaction' or 'Experience of Space and Place'. It's about how a building is embedded in its context and how it relates to it. Besides that, it also consists of spatial ideas such as 'Peril and Mystery' to design appealing spaces. (Zhong et al., 2022; Kellert, 2018; Kellert et al., 2008)

- Prospect and Refuge** - Using both wide and narrow spaces in combination to create varying atmospheres for contrast; theories state that there might be certain landscapes that humans prefer based on their evolution (Moura et al., 2018)

- Complexity and Order** - The idea is to create a balance between monotony and chaos in space by creating hierarchies and adding 'information richness'; it can be done through patterns, colors and with the help of computational design tools (Hildebrand, 2008; Zhong et al., 2022)

- Enticement (Peril and Mystery)** - Cantilever, bridges, edges or contrasting spatial sizes that are uncertain and enticing, which can add to the sensual experience; designing spaces that are evoking emotions of awe and wonder, where not everything is predictable compared to an experience in the 'wilderness' (Heerwagen & Gregory, 2008)

- Connection to Place** - Buildings are placed in a context, so it's about connecting and contextualizing, not just physically on a geographical level, but also historically; this can be done through inside-outside connections, specific views or using local plant species or materials (Zhong et al., 2022)

- Connection of Spaces** - It includes the aspect of mobility and how people move from one space to the other, in terms of exterior-interior connections, but also in general interior spaces; biophilic design actions can be the use of courtyards or gardens to give a chance for interaction (Kellert, 2018; Zhong et al., 2022; Lau et al., 2014)

3 | Benefits of Biophilic Design

Benefits of Biophilic Design on:

1. General Wellbeing
2. Cognitive Performance
3. Creativity
4. Physical Health
5. Environmental Awareness

In the following chapter, I will present a selection of research papers that have conducted the positive impact of Biophilic Design actions and in general 'Nature' on five different factors.

However, since Biophilic Design is a relatively young research field, it has been stated that even though there seems to be scientific evidence that natural elements and features implemented into architectural design can enhance wellbeing and evoke positive biological responses, there are still areas where more research needs to be done (Zhong et al., 2022).

The World Health Organization defines mental health as “a state of mental well-being that enables people to cope with the stresses of life, realize their abilities, learn well and work well, and contribute to their community” and “is more than the absence of mental disorders” (WHO, 2022), which can be simplified as “symptoms of positive feelings and positive functioning in life” (Keyes, 2002).



Due to an increasing urbanization and densification, in relation to a loss of nature and green space, has led to a change of human lifestyle and disconnection from the natural environment. Research has conducted that this disconnection is can be a part of mental health issues or can be improved through including 'nature' again through approaches such as Biophilic Design, while also having a crucial impact on a sustainability. (Capaldi et al., 2015)

References:

- Capaldi, C. A., Passmore, H., Nisbet, E. K., Zelenski, J. M., & Dopko, R. L. (2015). Flourishing in nature: A review of the benefits of connecting with nature and its application as a wellbeing intervention. *International Journal of Wellbeing*, 5(4), 1–16. <https://doi.org/10.5502/ijw.v5i4.449>
- Martin, L., White, M. P., Hunt, A., Richardson, M., Pahl, S., & Burt, J. (2020). Nature contact, nature connectedness and associations with health, wellbeing and pro-environmental behaviours. *Journal of Environmental Psychology*, 68, 101389. <https://doi.org/10.1016/j.jenvp.2020.101389>
- Zhong, W., Schröder, T., & Bekkering, J. (2022). Biophilic design in architecture and its contributions to health, well-being, and sustainability: A critical review. *Frontiers of Architectural Research*, 11(1), 114–141. <https://doi.org/10.1016/j.foar.2021.07.006>

Cognitive functioning is defined as “the performance of the mental processes of perception, learning, memory, understanding, awareness, reasoning, judgment, intuition, and language” (APA, n.d.), while performance describes abilities such as how well humans can focus on tasks, the level of short-term memory or general activity (Allen et al., 2016). This aspect correlates to work productivity and academic performance.



Some studies conducted how natural elements and environments, hence Biophilic Design, seem to enhance humans' cognitive performance more compared to urban settings. One theory in this area is called the Attention Restoration Theory (ART), which deals with the topic of restoration of mental fatigueness, which seems to happen faster in 'nature'. (Berman et al., 2018)

References:

- Allen, J. G., MacNaughton, P., Satish, U., Santanam, S., Vallarino, J., & Spengler, J. D. (2016). Associations of Cognitive Function Scores with Carbon Dioxide, Ventilation, and Volatile Organic Compound Exposures in Office Workers: A Controlled Exposure Study of Green and Conventional Office Environments. *Environmental Health Perspectives*, 124(6), 805–812. <http://doi.org/10.1289/ehp.1510037>
- Berman, M. G., Jonides, J., & Kaplan, S. (2008). The cognitive benefits of interacting with nature. *Psychological Science*, 19(12), 1207–1212. <https://doi.org/10.1111/j.1467-9280.2008.02225.x>
- Mason, L., Ronconi, A., Scrimin, S., & Pazzaglia, F. (2022). Short-term exposure to nature and benefits for students' cognitive performance: A review. *Educational Psychology Review*, 34(2), 609–647

A widely agreed definition of 'Creativity' was developed by the psychologist Guilford (1950) and says that “creative thinking involves sensitivity, curiosity, and flexibility in adopting different perspectives to a given challenge, and to branch out into new channels of thought” (van Rompay & Jol, 2016).



Architecture seems to be able to support creative thinking processes through the use of Biophilic Design Patterns. A study, conducted by researchers from the 'Universitat Jaume I' in Spain, found out that people in classrooms including natural features, both real and simulated, produced more ideas than the ones compared to the “neutral classroom” settings (Chulvi et al., 2020b).

References:

- Chulvi, V., Agost, M. J., Felip, F., & Gual, J. (2020). Natural elements in the designer's work environment influence the creativity of their results. *Journal of Building Engineering*, 28, 101033. <https://doi.org/10.1016/j.jobbe.2019.101033>
- van Rompay, T. J., & Jol, T. (2016). Wild and free: Unpredictability and spaciousness as predictors of creative performance. *Journal of Environmental Psychology*, 48, 140–148. <https://doi.org/10.1016/j.jenvp.2016.10.001>
- Williams, K. J., Lee, K. E., Hartig, T., Sargent, L. D., Williams, N. S., & Johnson, K. A. (2018b). Conceptualising creativity benefits of nature experience: Attention restoration and mind wandering as complementary processes. *Journal of Environmental Psychology*, 59, 36–45. <https://doi.org/10.1016/j.jenvp.2018.08.005>

The anthropocentric world view approach sees humans in the center of the system. The effect of climate change shows that this human-centric behavior isn't sustainable and would lead in the long-term to an increase of climate catastrophes, a decrease of biodiversity and general destruction of the global ecosystem.



Biophilic Design can't just have an immediate positive impact on its users and urban environment, it also promotes pro-environmental behavior and awareness (Richardson & Butler, 2022). This can be especially interesting in children's education to foster an environmental awareness from a young age (Yilmaz et al., 2023).

References:

- Anderson, D. J., & Krettenauer, T. (2021). Connectedness to Nature and Pro-Environmental Behaviour from Early Adolescence to Adulthood: A Comparison of Urban and Rural Canada. *Sustainability*, 13(7), 3655. <https://doi.org/10.3390/su13073655>
- Ghaziani, R., Lemon, M., & Atmodiwirjo, P. (2021). Biophilic design patterns for primary schools. *Sustainability*, 13(21), 12207. <https://doi.org/10.3390/su132112207>
- White, R. (2004). Young children's relationship with nature: Its importance to children's development & the earth's future. *White Hutchinson Leisure & Learning Group*. <http://www.whitehutchinson.com/children/articles/childreennature.shtml>
- Yilmaz, S., Vural, H., & Yilmaz, H. (2023). Effects of botanical gardens on student environmental perception. *Ecological Informatics*, 73, 101942. <https://doi.org/10.1016/j.ecoinf.2022.101942>

To stay healthy humans need to be physical active, which can increase general lifetime and reduce the risk of cardiovascular diseases or diabetes (Pretty et al., 2004). However, due to the development of people living in cities created a more sedentary lifestyle and people becoming less physical active (Herrington & Brussoni, 2015).



Studies have conducted the relation of close (outdoor) green spaces to motivate people to do physical activities such as talking a walk (Herrington & Brussoni, 2015). Additionally, play in natural environments seem to activate children to be more active, which could decrease the chance of obesity (Shanahan et al., 2016).

References:

- Herrington, S., & Brussoni, M. (2015). Beyond physical activity: the importance of play and Nature-Based Play Spaces for children's health and development. *Current Obesity Reports*, 4(4), 477–483. <https://doi.org/10.1007/s13679-015-0179-2>
- Pretty, J. (2004). How nature contributes to mental and physical health. *Spirituality and Health International*, 5(2), 68–78. <https://doi.org/10.1002/shi.220>
- Shanahan, D. F., Franco, L., Lin, B. B., Gaston, K. J., & Fuller, R. A. (2016). The benefits of natural environments for physical activity. *Sports Medicine*, 46(7), 989–995. <https://doi.org/10.1007/s40279-016-0502-4>

4 | Biophilic Space Catalogue

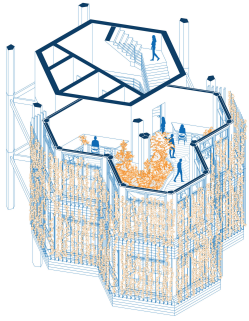
The presented Biophilic Space Catalogue is a development out of my literature research, 'Research by Design' explorations and based on that, architectural ideas of how Biophilic Space could look like in a mixed-used, vertical campus project.

These spaces include the knowledge that I've gained with my literature research. However, they also include speculation and ideas, that aren't fully proven on a scientific level to be general benefit.

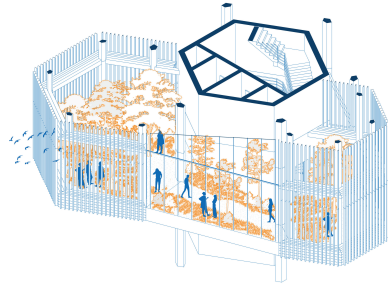
Therefore, with this Biophilic Space Catalogue I propose architectural design solutions that implement various Biophilic Design Patterns; Interpretations with the aim to benefit the users' overall well-being and academic performance of the students.

User Group	- <i>WHO is using this space?</i>
Function	- <i>WHAT is the spaced used for?</i>
Benefit(s)	- <i>WHICH benefit is the space especially promoting through its design?</i>
Biophilic Design Pattern	- <i>WHAT pattern(s) are applied to support a certain benefit?</i>
Space Characteristics	- <i>HOW are these elements translated into design actions and architectural space?</i>
	<i>This includes aspects of:</i>
	<i>Lighting (North, South etc.), Atmosphere (focused, busy or mixed), Indoor / Outdoor, Plant Size (grasses, shrubs etc.), Materiality, Texture, Organization (order / wild)</i>

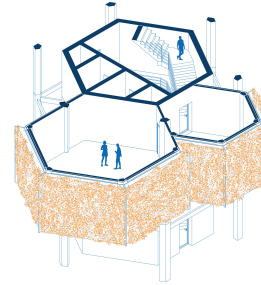
1. Learning Garden



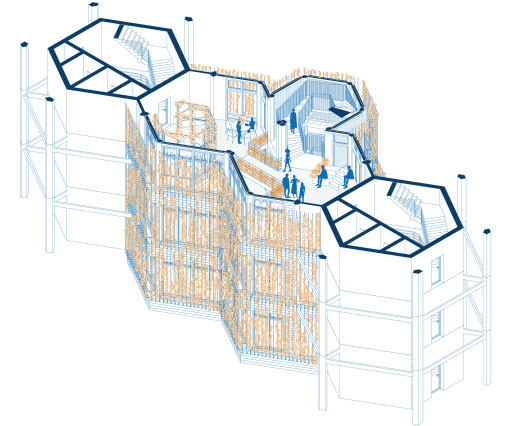
2. Study Forest



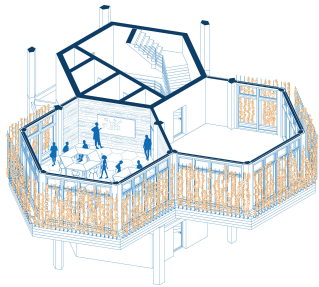
7. Immersive Nature (Virtual Reality)



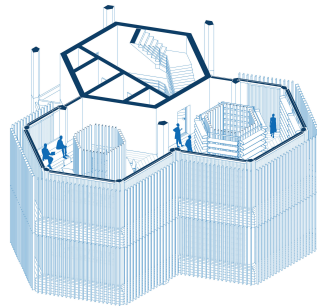
8. Coworking Landscape



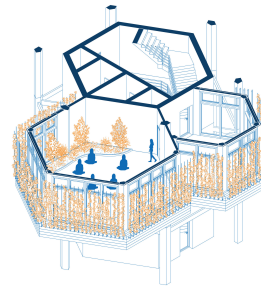
3. Biomimicry Classroom



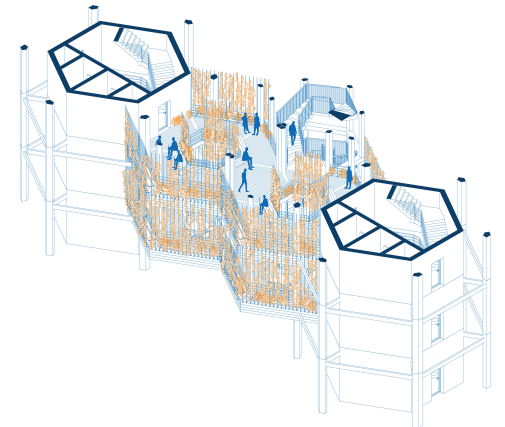
4. Light Library



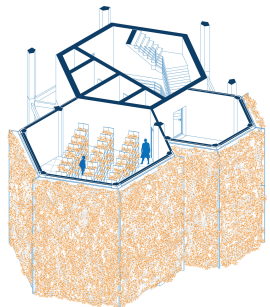
9. Mindfulness Garden -



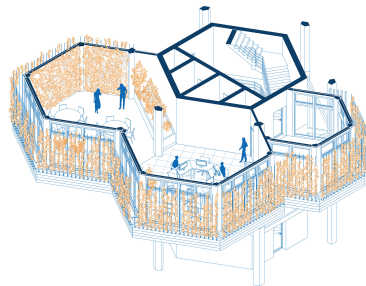
10. Vertical Park



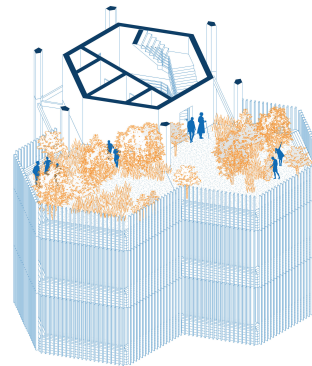
5. Vertical Farming -



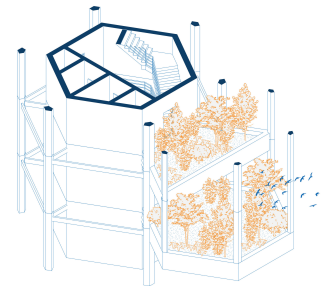
6. Biophilic Test Laboratory

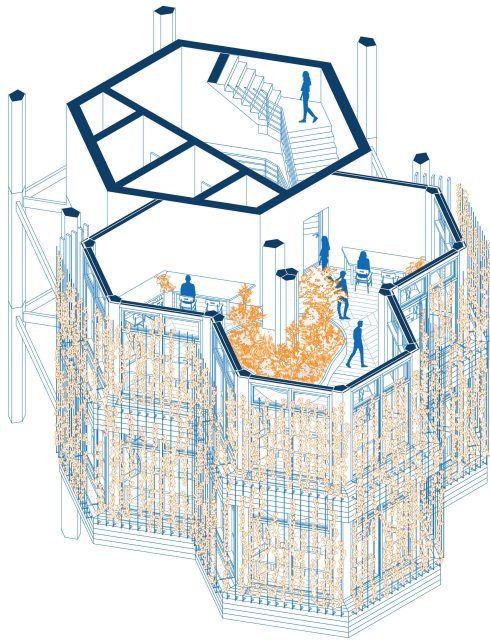


11. Forest Playground

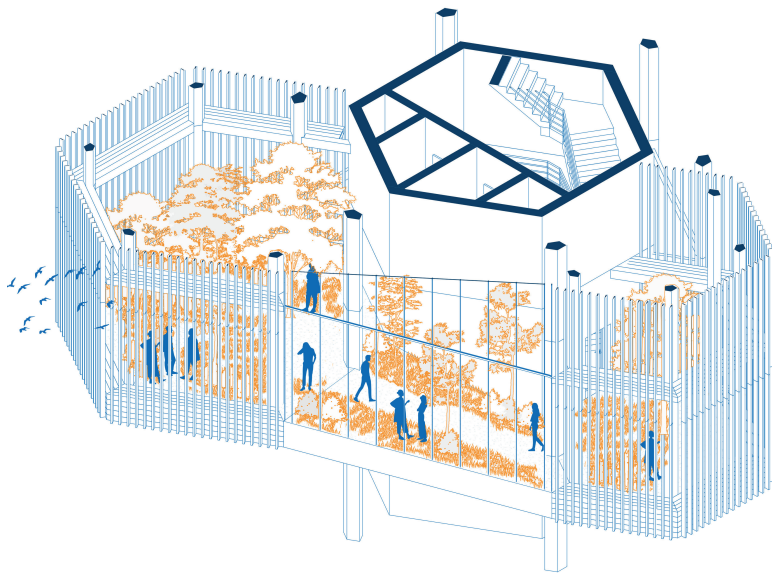


12. Wild Space

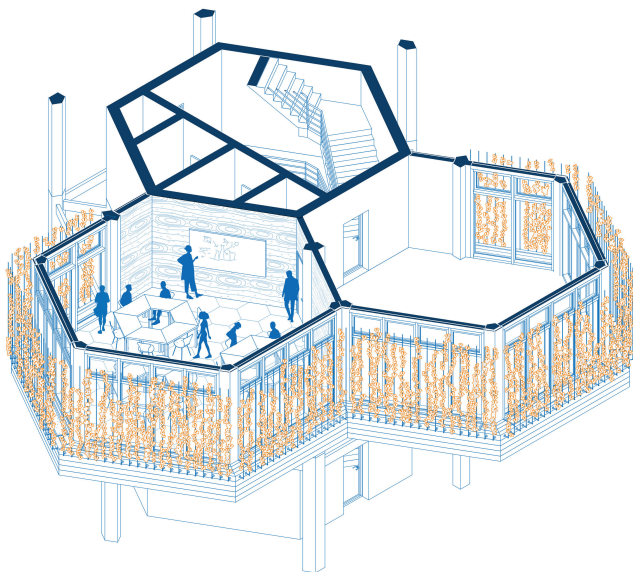




Name:	Learning Garden
User Group:	Students
Function:	Self-study
Benefit(s):	Cognitive Performance
Biophilic Design Patterns:	1. Incorporation: <i>Plants, Daylight</i>
Space Characteristics:	
- Atmosphere:	Focused, calm
- Lighting:	South
- In-/Outdoor:	Indoor
- Organization:	Order
- Plant size:	Grasses, flowers, small shrubs
- Materiality:	Timber flooring
- Facade:	Transparent



Name:	Study Forest
User Group:	Students
Function:	Self-study, Taking Breaks
Benefit(s):	Wellbeing, Creativity
Biophilic Design Patterns:	1. Incorporation: <i>Plants, Weather</i>
Space Characteristics:	
- Atmosphere:	Mixed - calm / busy
- Lighting:	South
- In-/Outdoor:	Outdoor
- Organization:	Mixed - order / wild
- Plant size:	Grasses, flowers, shrubs, small trees
- Materiality:	Soil (incl. grasses) or clay - natural flooring
- Facade:	Open



Name: Biomimicry Classroom

User Group: University

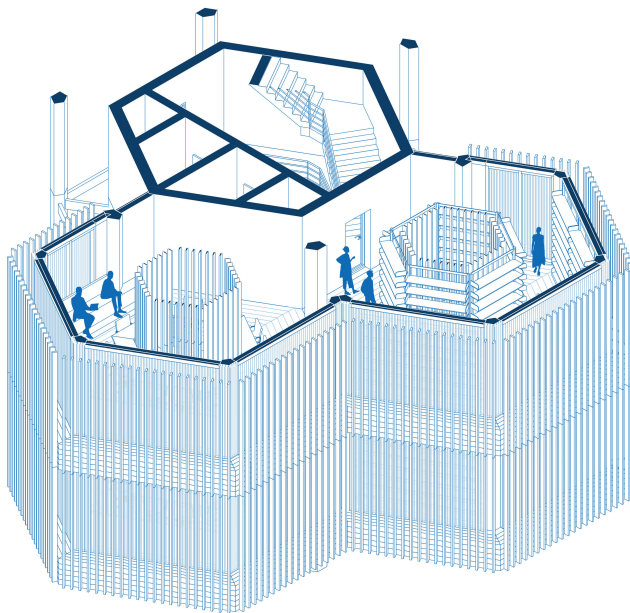
Function: Teaching

Benefit(s): Creativity

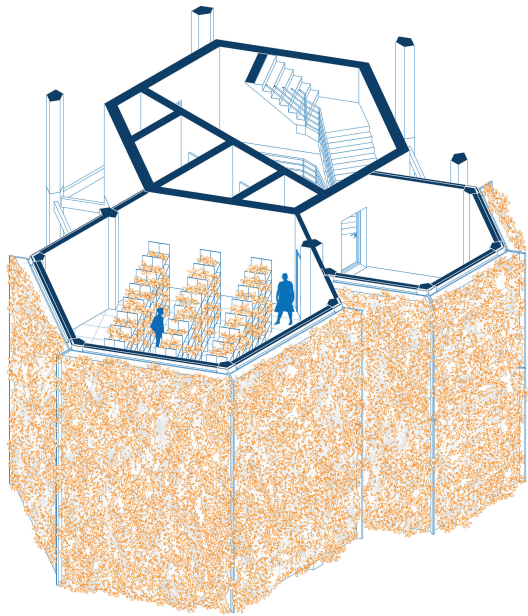
Biophilic Design
Patterns: 2. Inspiration: *Forms, Patterns, Textures*

Space Characteristics:

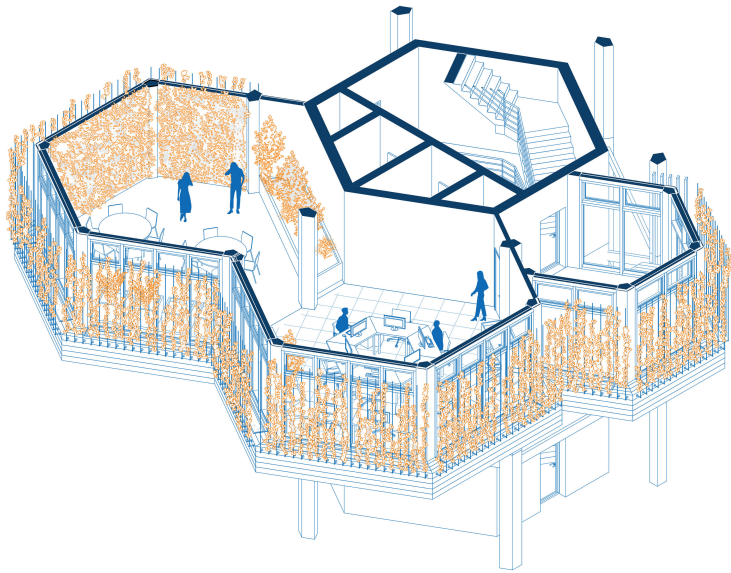
- Atmosphere: Energetic
- Lighting: East
- In-/Outdoor: Indoor
- Organization: Order
- Plant size: -
- Materiality: Mycelium Flooring, Fractal geometry on timber walls
- Facade: Transparent / Opaque



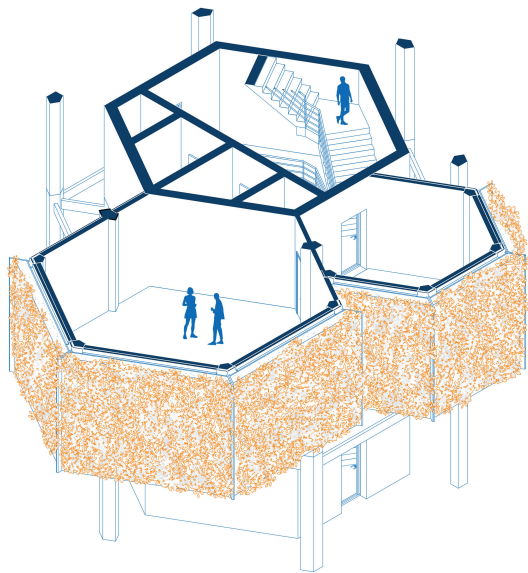
Name:	Light Library
User Group:	University, Office
Function:	Learning, Self-study
Benefit(s):	Cognitive Performance
Biophilic Design Patterns:	1. Incorporation: <i>Daylight (various)</i>
Space Characteristics:	
- Atmosphere:	Focused
- Lighting:	West / East
- In-/Outdoor:	Indoor
- Organization:	Order
- Plant size:	-
- Materiality:	Polycarbonat walls, skylights, timber flooring
- Facade:	Translucent



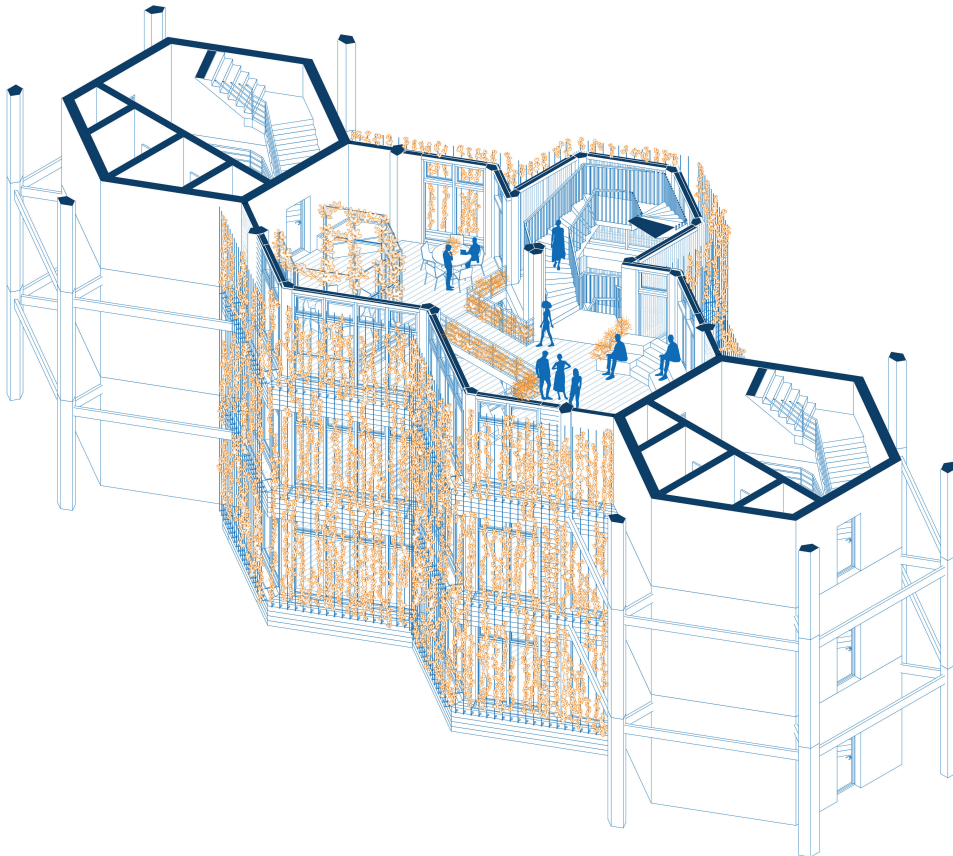
Name:	Vertical Farming
User Group:	University
Function:	Research
Benefit(s):	Environmental Awareness
Biophilic Design Patterns:	1. Incorporation: <i>Plants</i>
Space Characteristics:	
- Atmosphere:	-
- Lighting:	North
- In-/Outdoor:	Indoor
- Organization:	Order
- Plant size:	Depends on Research
- Materiality:	Sterile
- Facade:	Opaque



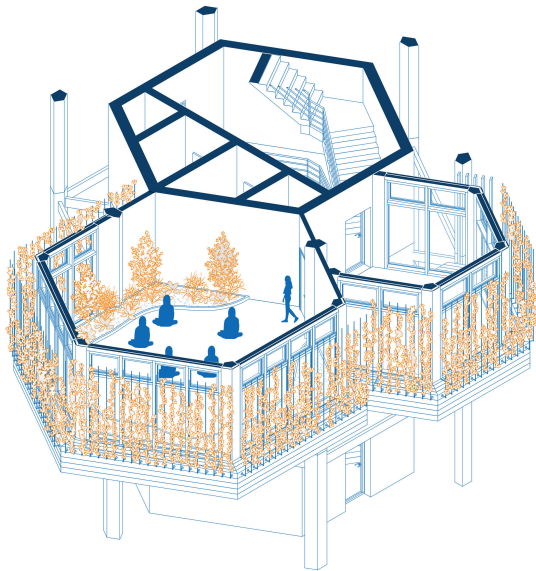
Name:	Biophilic Test Laboratory
User Group:	University
Function:	Research
Benefit(s):	Testing the effect of Biophilic Design Patterns
Biophilic Design Patterns:	Depends on Research
Space Characteristics:	
- Atmosphere:	Busy
- Lighting:	South
- In-/Outdoor:	Indoor
- Organization:	-
- Plant size:	-
- Materiality:	Sterile
- Facade:	Transparent / Opaque



Name:	Immersive Nature (Virtual Reality)
User Group:	University (incl. Public)
Function:	Experience, Research
Benefit(s):	Environmental awareness, Wellbeing
Biophilic Design Patterns:	2. Inspiration: <i>Images, Virtual Reality</i>
Space Characteristics:	
- Atmosphere:	Exciting
- Lighting:	North
- In-/Outdoor:	Indoor
- Organization:	Order
- Plant size:	-
- Materiality:	White
- Facade:	Opaque

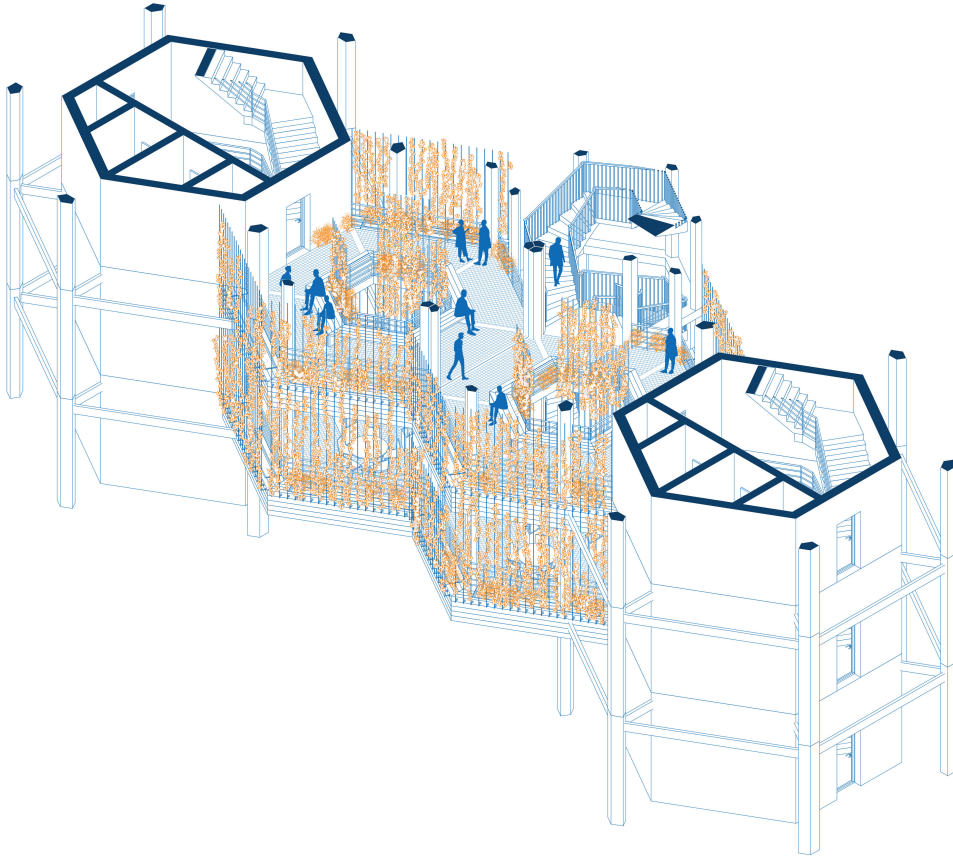


Name:	Immersive Nature (Virtual reality)
User Group:	Mixed: Offices / University
Function:	Working, Exchange, Collaboration
Benefit(s):	Creativity
Biophilic Design Patterns:	3. Interaction: <i>Prospect and Refuge</i> (through open workspaces and smaller ones)
Space Characteristics:	
- Atmosphere:	Busy
- Lighting:	East
- In-/Outdoor:	Indoor
- Organization:	Order
- Plant size:	Indoor plants, Planter Boxes
- Materiality:	Timber Flooring
- Facade:	Transparent



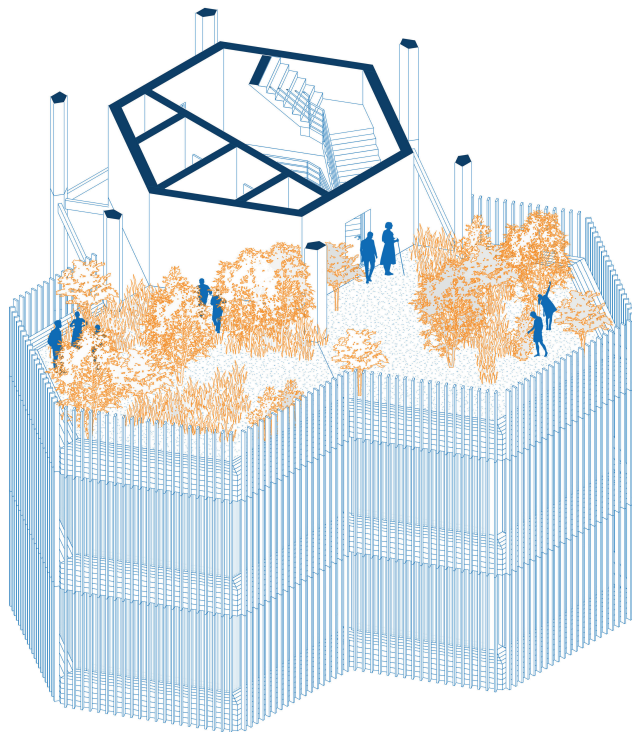
Name:	Mindfulness Garden
User Group:	University
Function:	Sports, Taking a Break
Benefit(s):	Physical Health
Biophilic Design Patterns:	1. Incorporation: <i>Plants, Daylight</i>
Space Characteristics:	
- Atmosphere:	Calm
- Lighting:	West
- In-/Outdoor:	Indoor
- Organization:	Order
- Plant size:	small-medium: grasses, flowers, shrubs
- Materiality:	Parquet
- Facade:	Transparent

- Vertical Park -

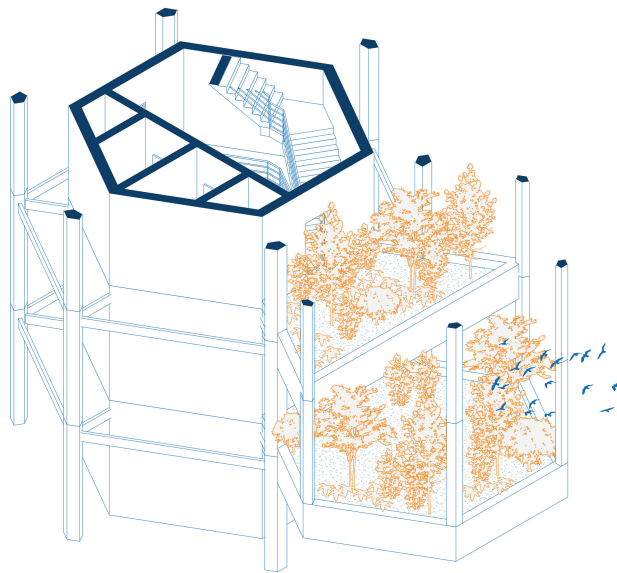


- Classification -

Name:	Vertical Park
User Group:	Public
Function:	Meeting, Exchange
Benefit(s):	Wellbeing
Biophilic Design Patterns:	3. Interaction: <i>Connection to Place</i>
Space Characteristics:	
- Atmosphere:	Busy, Energetic
- Lighting:	South
- In-/Outdoor:	Outdoor
- Organization:	Order
- Plant size:	Climbing plants
- Materiality:	Mesh steel flooring, Permeable
- Facade:	Open



Name:	Forest Playground
User Group:	Public
Function:	Playground for Children
Benefit(s):	Environmental Awareness, Physical Health
Biophilic Design Patterns:	1. Incorporation: <i>Plants, Animals</i>
Space Characteristics:	
- Atmosphere:	Open
- Lighting:	South
- In-/Outdoor:	Outdoor
- Organization:	Wild
- Plant size:	Grasses, flowers, shrubs, small trees
- Materiality:	Grass / Flower floor
- Facade:	Open



Name:	Wild Space
User Group:	Vegetation / Animals
Function:	Space for non-human organisms
Benefit(s):	Environmental Awareness
Biophilic Design Patterns:	1. Incorporation: <i>Plants, Animals</i>
Space Characteristics:	
- Atmosphere:	Calm
- Lighting:	South
- In-/Outdoor:	Outdoor
- Organization:	Wild
- Plant size:	Grasses, flowers, shrubs, small trees
- Materiality:	-
- Facade:	Open

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- Icon Sources -

In order of appearance:

Human (Problem Statement & Wellbeing):

Arif Hariyanto, <https://thenounproject.com/icon/human-6575428/>

Brain (Cognitive Performance):

Cédric Villain, <https://thenounproject.com/icon/brain-644083/>

Light Bulb (Creativity):

jk Lim, <https://thenounproject.com/icon/light-bulb-6939188/>

Environment (Environmental awareness):

iconixar, <https://thenounproject.com/icon/environment-3480683/>

Gym weight (Physical Health):

Oksana Latysheva, <https://thenounproject.com/icon/gym-835256/>

Fig. 1 Protestors holding sign, “Give us the Park”. (May 30, 1969) - Howard Erker, photographer. Gelatin silver print. From Collection of the Oakland Museum of California. The Oakland Tribune Collection.

(<https://picturethis.museumca.org/pictures/protestors-holding-sign-give-us-park>)

Fig. 2 Multiple sources compiled by World Bank (2024) – processed by Our World in Data. “Rural population” [dataset]. World Bank based on data from the UN Population Division, “World Development Indicators” [original data]. (<https://ourworldindata.org/urbanization>)

Fig. 3a Screenshot of a cover of a research paper by Ulrich (1984).

Fig. 3b Image from a book cover (Wilson, 1984). (<https://www.amazon.de/Biophilia-Edward-Wilson-1984-01-13/dp/B01K3ITDYW>)

Fig. 3c Image from a book cover (Kellert, 2018). (<https://www.amazon.com/Nature-Design-Practice-Biophilic/dp/0300214537>)

Fig. 3d This Daily Mail picture was taken at sunset from the top of Westminster Cathedral in 1953. London faced another killer smog in 1953 after 48 hours of fog trapped the smoke belching from millions of London’s chimney pots. (1953) - Photograph: Associated Newspapers / Rex Fea/Rex Features. (<https://www.theguardian.com/environment/gallery/2012/dec/05/60-years-great-smog-london-in-pictures>)

Fig. 3e Image from a book cover (Meadows et al., 1972). (<https://www.clubofrome.org/publication/the-limits-to-growth/>)

Fig. 3f Graphic of the Sustainable Development Goals by the United Nations. (n.d.) Sustainable Development Goals (SDGs) and disability | Division for Inclusive Social Development (DISD). (n.d.). <https://social.desa.un.org/issues/disability/sustainable-development-goals-sdgs-and-disability>. (<https://www.un.org/sustainabledevelopment>, “The content of this publication has not been approved by the United Nations and does not reflect the views of the United Nations or its officials or Member States”)

